

which was a month of phenomenal snowfall. In our computations we have ignored the rainfall because of a regrettable paucity of data and the insuperable difficulties encountered in all attempts to segregate the rain from the snow. However, the writer believes that in an average season the total rainfall will not exceed 10 per cent of the total precipitation. This rainfall factor and losses by evaporation and soil absorption probably account for the observed differences between the predicted and the actual change in level.

Second forecast, April 6.

Snowfall, December to March.....inches..	281
Normal snowfall, December to March.....do....	183
Percentage of normal fall.....	1.54
Normal change in level, April to July.....feet..	1.69
Probable change in level, April to July, $1.54 \times 1.69 =$do....	2.60
Actual lake level, Mar. 31 (above M. S. L.).....do....	6.228.10
Probable maximum stage for 1916.....do....	6.230.70
Actual maximum stage for 1916.....do....	6.230.65

Third forecast, May 4.

Snowfall, December to April.....inches..	281
Normal snowfall, December to April.....do....	193
Percentage of normal fall.....per cent..	146
Normal change in level, May to July.....feet..	1.26
Probable change in level, May to July, $1.46 \times 1.26 =$do....	1.84
Actual lake level, Apr. 30.....do....	6.228.56

Probable maximum lake stage for 1916.....do....	6.230.40
Actual maximum lake stage for 1916.....do....	6.230.65

First year trial forecasts, 1915.

By the same method as that described in the foregoing paragraphs, *trial estimates* of the maximum level of the lake for the summer of 1915 were made in the fall of that year.

The estimates for 1915 were based on 10 stations, instead of nine; the 10th station was Lewer's ranch, Nevada, which was dropped from the list because the observations were discontinued at that place in November, 1915.

In the Spring of 1916 another investigation was undertaken and completed for the purpose of ascertaining whether satisfactory results might be had by the same method, but with a smaller number of records. For that purpose we selected four stations—namely, Tahoe, Cal.; McKinney, Cal.; Marlette Lake, Nev.; and Bijou, Cal. In making this selection we had in mind the fact that at ordinary levels the average seasonal snowfall is appreciably less on the east side of Lake Tahoe than on the west side. The average snowfall for the entire Tahoe basin used in the second investigation was that based on the records for the four stations named.

CONCLUSIONS.

The results obtained in 1915, a season of light snowfall, and those for 1916, a season of heavy snowfall, indicate that the proposed method is practical, and that the estimates based on snowfall records for four stations are of practically the same degree of accuracy as those based on a larger number of records.

ANNUAL RISE IN THE COLUMBIA RIVER.

By FLOYD D. YOUNG, Assistant Observer.

(Abstract.)

As is well known the annual rise in the Columbia River is due to the melting of the accumulated snow of spring in the higher levels of headwater streams, and is, there-

fore, conditioned to a greater or less extent upon the amount of snow which remains upon the ground until early summer and also the temperature over the watershed during the months when melting is going on.

The following table, compiled from the MONTHLY WEATHER REVIEW, shows the temperature and precipitation over the northern Plateau during the snowfall season of 1915-16.

TABLE 1.—Temperature and precipitation over the northern Plateau.

Month.	Mean temperature.	Departure.	Mean precipitation.	Departure.
December.....1915.....	°F. 32.2	°F. +0.2	Inches. 1.58	Inches. -0.2
January.....1916.....	19.9	-8.9	1.92	+0.3
February.....	33.9	+1.8	2.26	+0.9
March.....	43.8	+3.6	1.97	+0.4
April.....	49.8	+0.8	0.97	-0.4

The above table shows that the temperature was below normal and the precipitation above normal. These conditions were probably more pronounced at higher levels, for many snowfall stations reported more snow than had been previously recorded, and many old settlers reported the greatest depth of snow in the mountains they had ever known.

The following summary was published by the Weather Bureau in the Oregon Snowfall Bulletin for March, 1916:

Last winter was unusually cold, and the snowfall not only began earlier in the fall and ended later in the spring than usual, but the amounts that fell were the heaviest in years. The snow now in the mountains is well packed and has a high water content. Much of that which has so far melted, soaked into the ground and the soil is well moistened to a good depth. Under normal temperature conditions during April and May higher water than usual will occur during the annual rise in the Columbia River and those cultivating bottom lands should govern themselves accordingly.

The upper tributaries of the Columbia began to rise early, the Kootenai near the end of April, and the Pend d'Oreille early in May; the upper Columbia itself rose gradually and steadily after the first of April. Cold weather near the end of May temporarily checked the rise in the tributaries and the crests occurred in the Pend d'Oreille early in July and in the Kootenai late in June. The Snake River reached the crest later than usual, about the middle of June, but was well on its way down when the crest in the Columbia arrived.

The small discharge of the Snake River was the most unexpected feature of the flood. The highest stage reached at Lewiston was 5.3 feet below the flood stage and at Riparia the crest was 13 feet below the flood stage. As usual, the Columbia at Umatilla, and to a lesser extent the backwater from the Columbia at Portland, closely followed the movements of the Snake River.

The flood stage was reached at Portland, Oreg., on May 7, but cooler weather over the upper watershed caused the water to recede on May 19. The river was again above the flood stage from May 23 to 25 inclusive, after which it fell about 0.5 foot, remaining nearly stationary until June 8 when it began to rise again. The crest was reached on July 4 and 5 with a stage of 23.9 feet. This is the latest date on which the crest of the annual rise has occurred at Portland since gage readings were begun at that place; the latest date previously recorded was July 2, 1880. The crest at Portland was accurately forecast as to time of occurrence, but the actual height was 0.2 foot higher than the stage forecast,

due to a rapid rise in the Willamette. Table 2, below, shows the highest stages reached at the various gaging stations along the river.

TABLE 2.—Highest stages reached during annual rise of the Columbia River, 1916.

Station.	River.	Flood stage.	Highest stage, 1916.	Dates.
		<i>Feet.</i>	<i>Feet.</i>	
Bonnere Ferry.....	Kootenai.....	26	32.7	June 22.
Newport.....	Pend d'Oreille	16	23.8	July 6 to 9.
Marcus.....	Columbia.....	24	33.8	June 30 & July 5.
Wenatchee.....	do.....	40	46.4	June 30 to July 1.
Kennewick.....	do.....	25	20.8	June 30.
Weiser.....	Snake.....	14	10.3	June 20 to 21.
Kamiah.....	Clearwater.....	12	13.7	June 19.
Lewiston.....	Snake.....	22	16.7	June 20.
Riparia.....	do.....	30	17.0	June 19.
Umatilla.....	Columbia.....	25	23.9	June 30.
The Dalles.....	do.....	40	40.4	July 1.
Cascade Locks.....	do.....	46	32.7	July 1.
Vancouver.....	do.....	15	24.5	July 2 to 6, incl.
Portland.....	Willamette.....	15	23.9	July 4 to 5.

MEAN LAKE LEVELS DURING JULY, 1916.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Aug. 3, 1916.]

The following data are reported in the Notice to Mariners of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during July, 1916:	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
Above mean sea level at New York.....	603.65	581.16	573.24	247.93
Above or below—				
Mean stage of June, 1916.....	+0.17	+0.22	—0.02	+0.07
Mean stage of July, 1915.....	+1.40	+1.26	+1.20	+2.80
Average stage for July, last 10 years.....	+1.25	+0.29	+0.50	+1.16
Highest recorded July stage.....	—0.17	—2.42	—1.17	—0.79
Lowest recorded July stage.....	+2.17	+1.26	+1.78	+3.34
Average relation of the July level to—				
June level.....	+0.2	0.0	—0.1	—0.1
August level.....	—0.2	0.0	+0.1	+0.3